PRIMAVERA

SPLINTER SESSION

DOES HIGH RESOLUTION CLIMATE MODELLING MATTER

Prepared and hosted by: Dragana Bojovic and Yohan Ruprich (BSC), Bernd Eggen, Helen Hanlon, Erika Palin and Galina Guentchev (Met Office), Janette Bessembinder, Eveline van der Linden and Rein Haarsma (KNMI), Paula Gonzalez (University of Reading) and Philipp Stanzel (PÖYRY)

Met Office

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

University of Reading

Royal Netherlands Meteorological Institute *Ministry of Infrastructure and the Environment*

PRIMAVERA

Go to

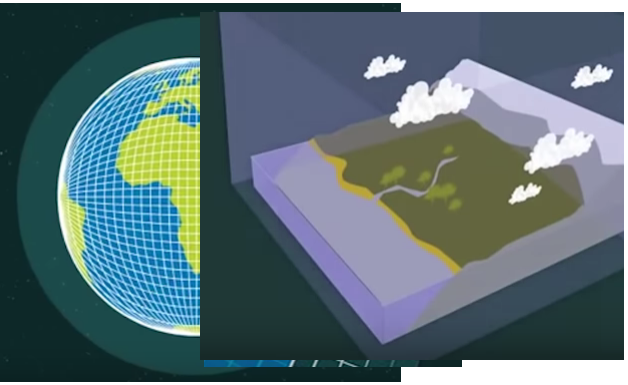
www.menti.com

and use the code

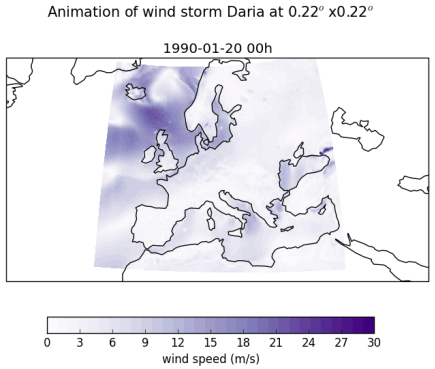
61 75 43

See the results here

WHAT IS PRIMAVERA?



PRIMAVERA is a European Commission-funded project about designing and running **new high resolution global climate models,**



and assessing their **ability to simulate societally important processes,**

and thereby providing information to **support climate risk assessment activities** across Europe.

© Network Rail

PRIMAVERA THEMES

Innovations in modelling
- Harnessing the latest climate model developments

Flagship simulations for CMIP6
- Linking in with major international (IPCC-related) modelling activities

Drivers of European climate
- What key processes influence the climate of Europe?

Process-based assessment
- How well do PRIMAVERA models simulate key processes?

Climate risk assessment & user engagement
- Consultation and collaboration with stakeholders

CLIMATE MODELLING IN PRIMAVERA

- Atmosphere only simulations **completed** for the historical period
- Coupled models simulations are **under way** for the historical period and will run for the future period up to 2050
- New set of modelling experiments and a set of bespoke high-resolution climate model simulations, based on what we learnt in the project and feedback received from users

ERE3.1 - Gonzalez & Brayshaw explore added value of sub-6hrly wind data from global climate models for energy applications

ERE3.1 - Gonzalez et al. investigate impacts of North Atlantic jet on surface wind projections for windpower over W Europe

Thu 12 April, 17:30-19:00

Palin et al. present PICO of progress & challenges in user engagement activities in PRIMAVERA

Friday 8:30am-10am

High Resolution session (AS5.10/BG1.13/CL5.08/HS3.6/OS1.18) Friday 13 April

Roberts et al. investigate resolution sensitivity of #Atlantic tropical cyclone climatology including their tracks

14:15-14:30

Mavilia et al. study simulation of Euro-Atlantic weather regimes & impacts of resolution & stochastic physics

14:45-15:00

Vanniere et al. study sensitivity to resolution of hydrological cycle and moisture transport in several GCMs

16:15-16:30

2020 - E.Scoccimarro et al. investigate extratropical transition of tropical cyclones & impacts on precipitation in W. Europe

2574 - Haarsma et al. study impacts of ocean eddies in western boundary currents on mid-latitude interannual variability

4052 - Klaver et al. study atmospheric energy exchange across scales in global climate model at two different resolutions

7670 - Roberts et al. show results from ECMWF operational Integrated Forecast System run under HighResMIP protocol

7884 - Schiemann & Athanasiadis on representation of blocking in high-resolution multi-model climate simulations

12637 - Vidale et al: impacts of climate model resolution on morphology of Atlantic tropical cyclones in AMIP simulations

Friday, 13 April, 17:30-19

13340 - Wang et al. investigate impacts of Siberian snow changes on European climate in EC-Earth3 (various resolutions)

14084 - Athanasiadis et al. study impacts of resolution & other processes on North Atlantic mid-latitude jet in climate models

14430 - Bakeyet al. investigate impacts of high model resolution on extreme precipitation & Euro-Atlantic storminess

17903 - Roberts et al. introduce PRIMAVERA - coordinated global high resolution coupled climate modelling

14606 Bakey et al. investigate variability of posttropical cyclones & associated rainfall in reanalysis data [

14794 in AS4.3 – Vanniere et al. study the sensitivity of the water balance of extratropicalcyclones to climate model resolution

USER ENGAGEMENT APPROACHES

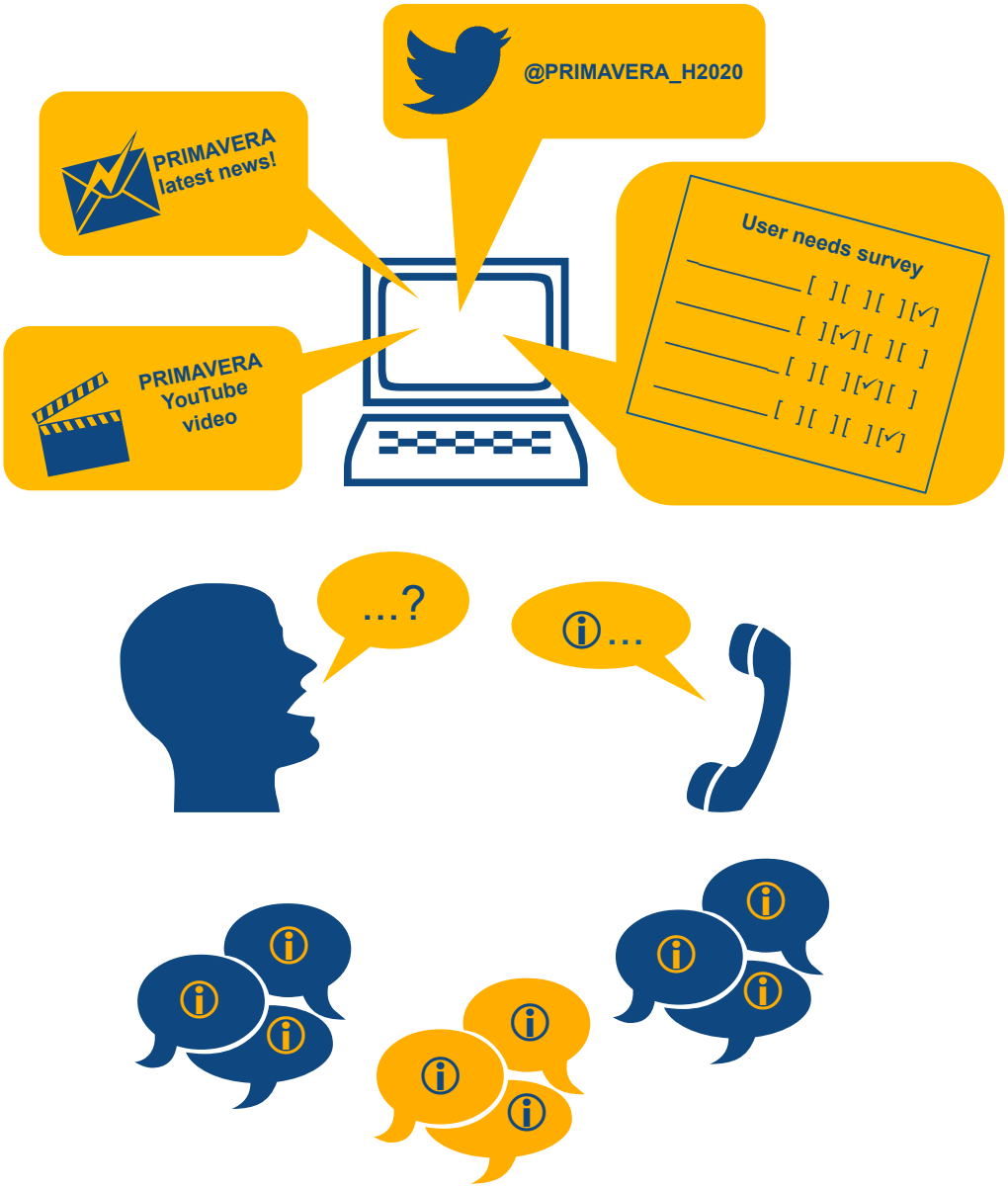
Various communication channels:

User Interface platform

Factsheets

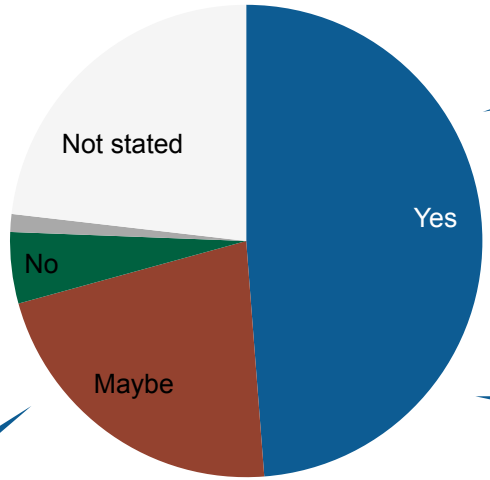
Survey and Interviews with users from energy, transport, agriculture, health, water management, insurance and other sectors

Co-design of the project outputs with users


@PRIMAVERA_H2020
PRIMAVERA latest news!
PRIMAVERA YouTube video
User needs survey
...?

RESULTS FROM THE SURVEY

Would the higher-resolution information provided by PRIMAVERA be useful to your organisation?



Best predictability of **extreme events**

Hazard information at these resolutions **rarely exists** at present

Good starting point for **further downscaling**

Impact studies require local information

Focuses only to the **hazard** (physical event itself), while we deal with **risk**

Finer scale helps, but the main question is: **how to use the available data?**

We have **very good resolution**

Not applicable

“DATA”, OR “INFORMATION”?

EXAMPLES

Raw model output	"Minimally-processed" data	Heavily post-processed data
• The data exactly as produced by the model runs	• Bias-corrected data • Spatially / temporally averaged data • Basic metrics such as threshold exceedance	• Sector-specific metrics/indicators • Data in a bespoke format that can be ingested by customer-specific models

← DATA INFORMATION →

A few users, mostly working in research

Most users

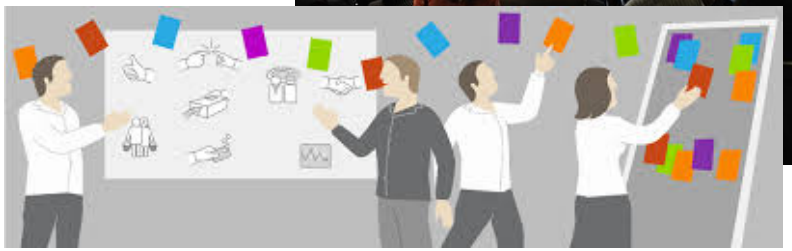
USER INTERFACE PLATFORM

Welcome to the PRIMAVERA User Interface Platform. The aim of this website is to disseminate the results of the project to users and potential users. The new climate information arising from PRIMAVERA high resolution simulations is presented in the context of different impact sectors. Also, specific results are presented in an interactive way by using storymaps. As the project is still ongoing, new content will be added regularly.

PROPOSED NEXT STEPS

- New **factsheets and storymaps**

- Virtual and Face to face **meetings** and **workshops**
  - Sectoral or thematic
  - Engaging interaction and collaboration between scientists and practitioners



- **Use cases**
  - Developed through collaborative and iterative process

- **Get in** touch at: prima_enquires@bsc.es

PRIMAVERA MODELLLING – WHAT WE LEARNT

TROPICAL CYCLONES

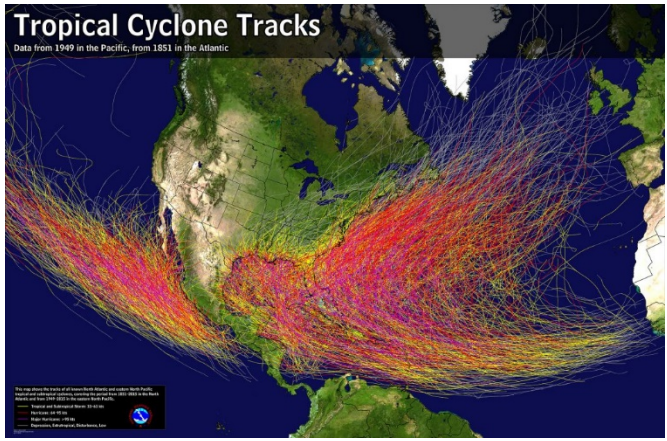
YOHAN RUPRICH-ROBERT (BSC)

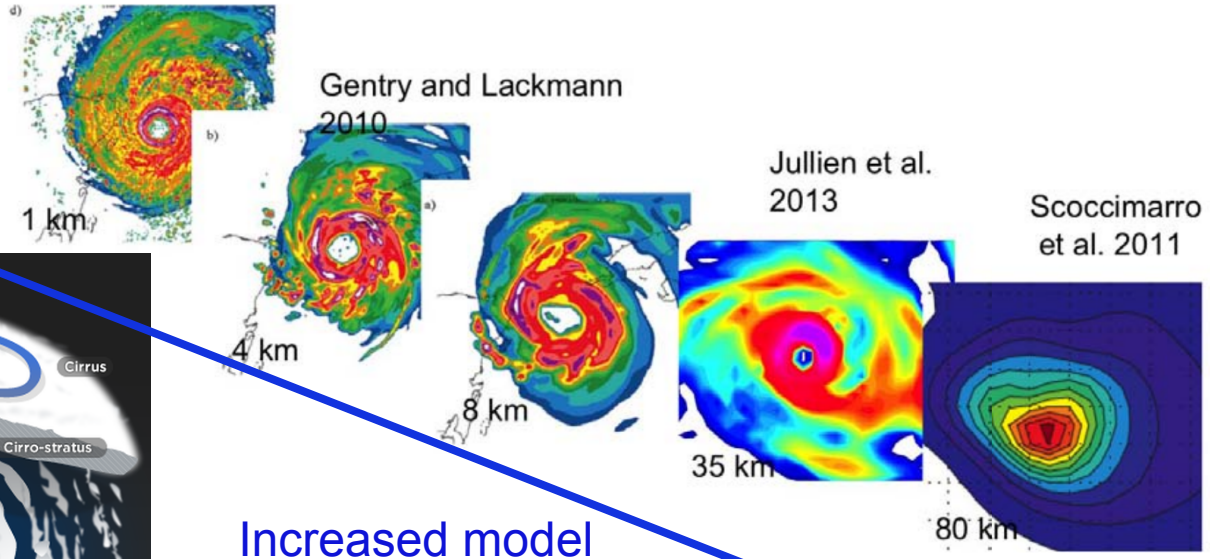
Tropical Cyclones

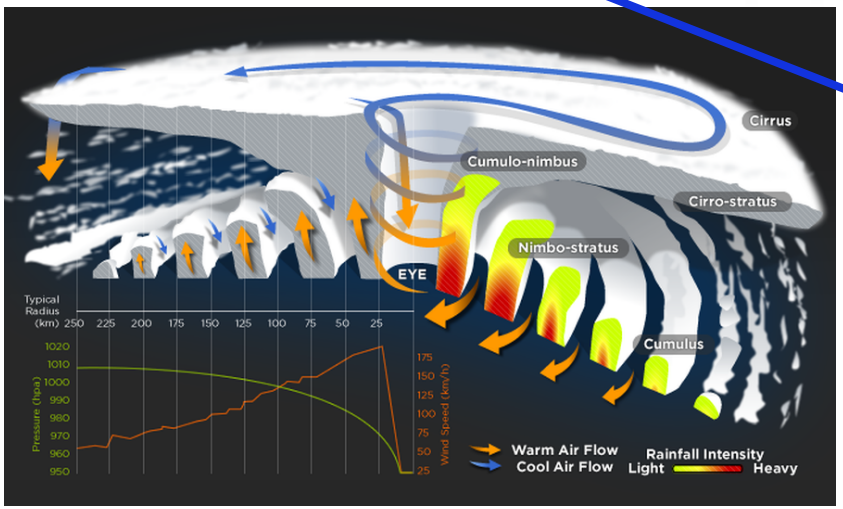
Tropical Cyclones can have dramatic impacts on society:

- Land fall cyclones (Katrina 2005, Harvey 2017)
- Transition into extratropical storms
- Extreme precipitation event over South Europe

Better understand / predict Tropical Cyclones will enhance our society resilience to such natural hazard

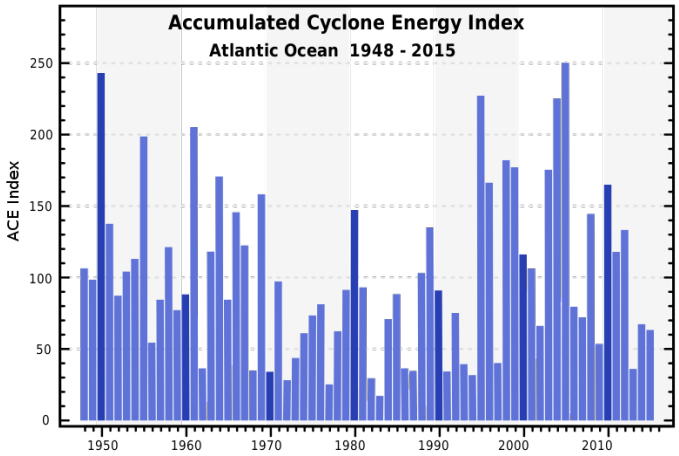




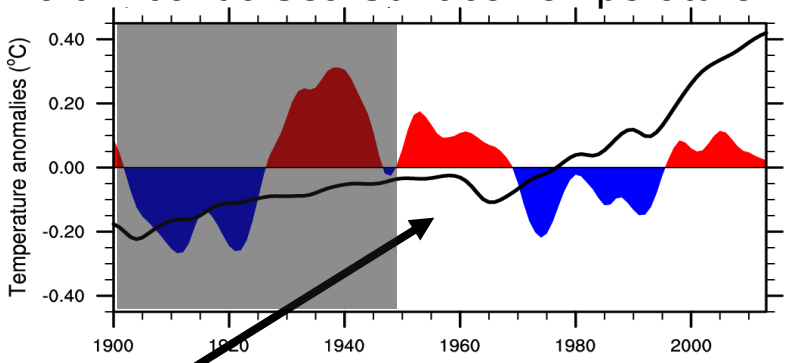


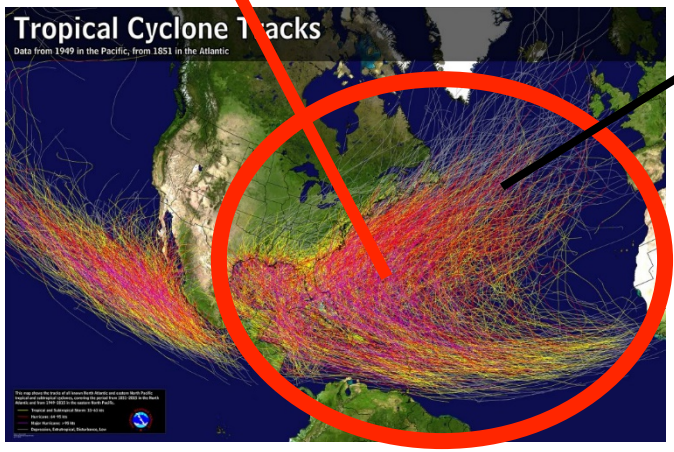
Decadal modulation of Tropical Cyclones by SST

North Atlantic Tropical Cyclone Energy

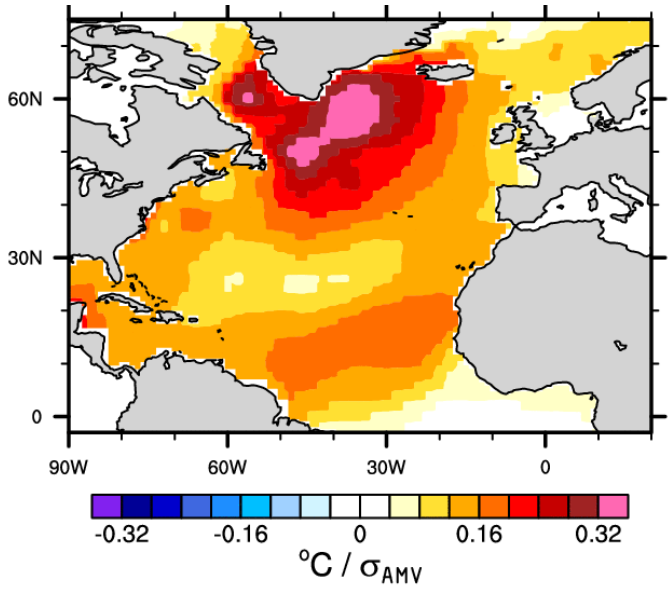


North Atlantic Sea Surface Temperature



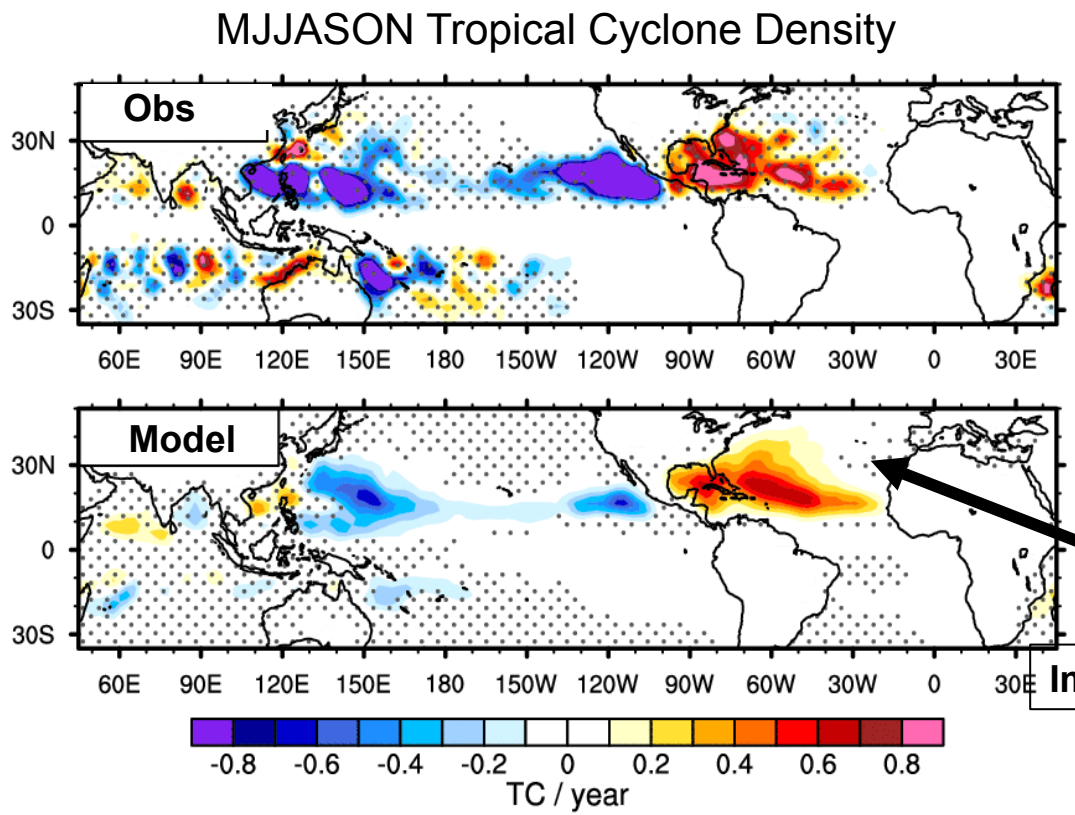


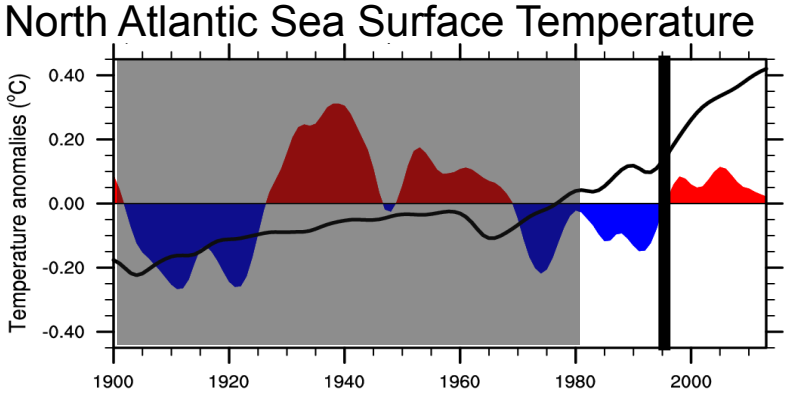
Atlantic Multidecadal Variability

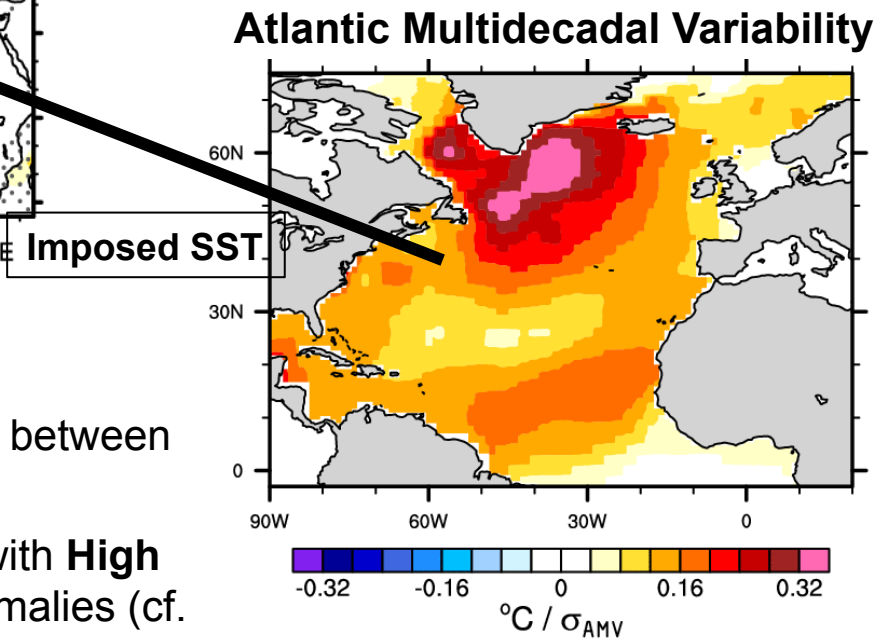


North Atlantic Tropical Cyclone activity appears modulated by sea surface temperature at decadal timescale

Decadal modulation of Tropical Cyclones by SST – Primavera WP5







Top left: shows difference of tropical cyclone density between the 1996-2011 and 1980-1995 periods

Bottom left: show results of experiment performed with **High Resolution climate models**, in which observed anomalies (cf. bottom right) where imposed only over North Atlantic

The model is able to represent the observed modulation of tropical cyclones

Can we expect more Ophelias in a warmer world?

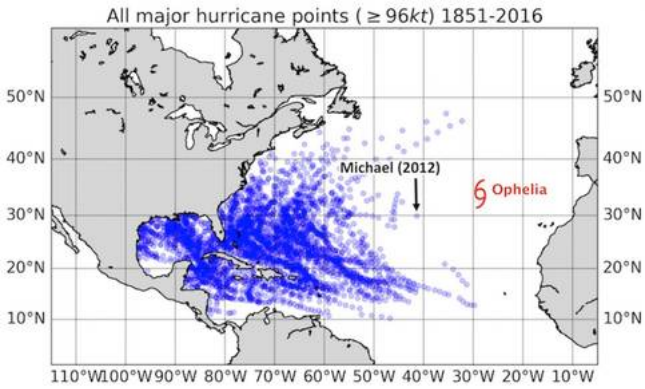
What can high resolution simulations tell us?

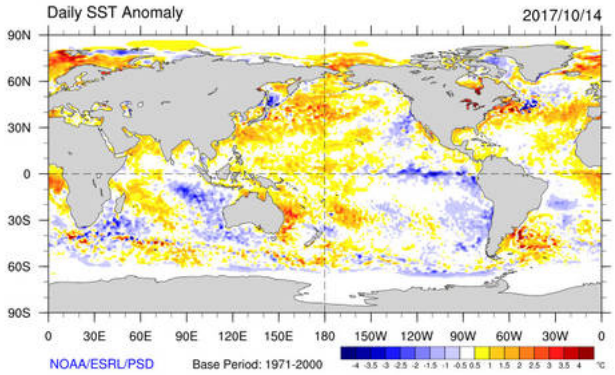
Rein Haarsma, Michiel Baatsen, Mark Dekker, Hylke de Vries,
Aarnout van Delden

Royal Netherlands Meteorological Institute (KNMI)

Ophelia

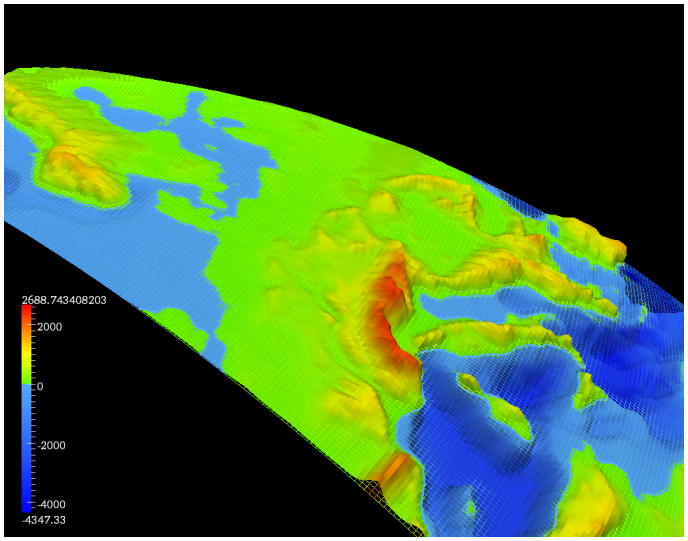
- Took a very easterly pathway
- Reached category 3 intensity close to Europe.
- Abnormal warm SST's





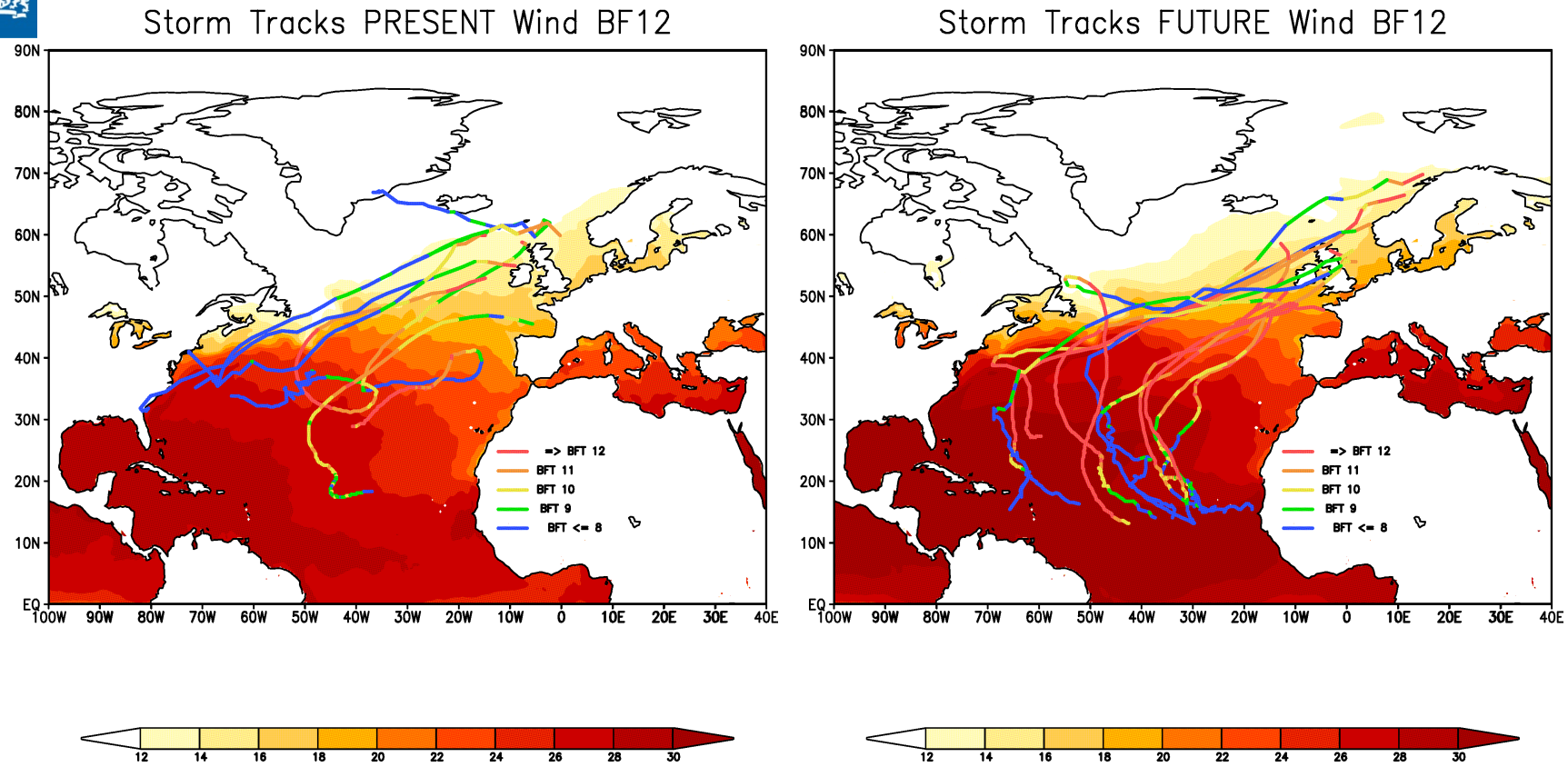
Will there be more Ophelias in a warmer climate?

- High resolution model (EC-Earth ~25 km) for reliable simulation of hurricnaes
- Simulations for now (2005) and future (2090) using RCP4.5 scenario
- Time slices of 30 years

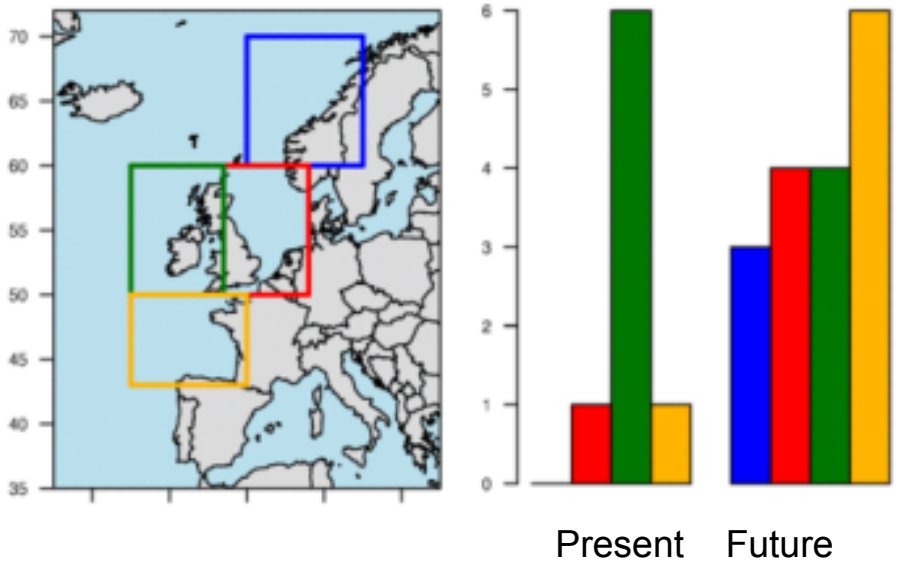


T799 ~25 km

Hurricanes can reach Europe in a warmer climate



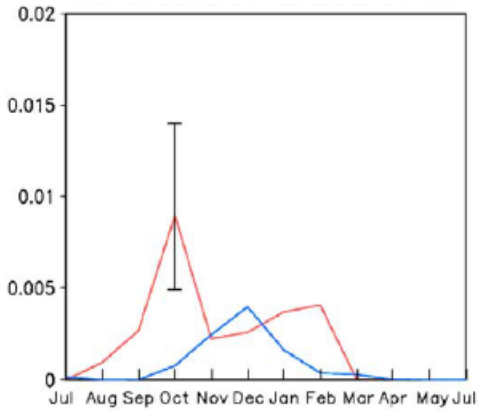
Haarsma et al., GRL, 2013



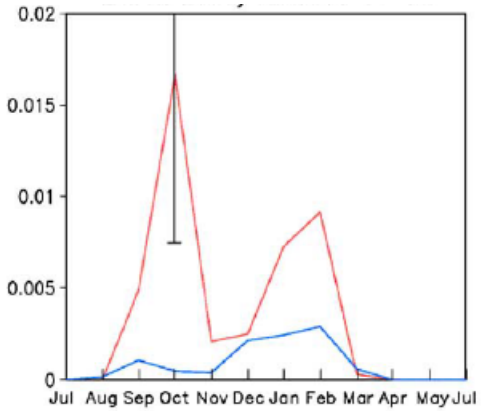
Number of storms with hurricane strength (Bf 12)

Frequency BF 12 storms
Blue present, Red Future

North Sea



Gulf of Biscay

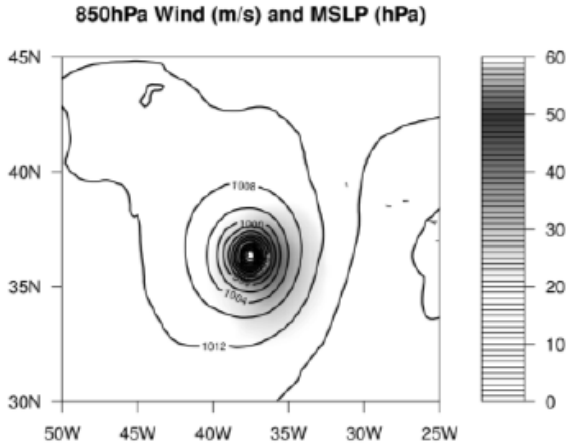


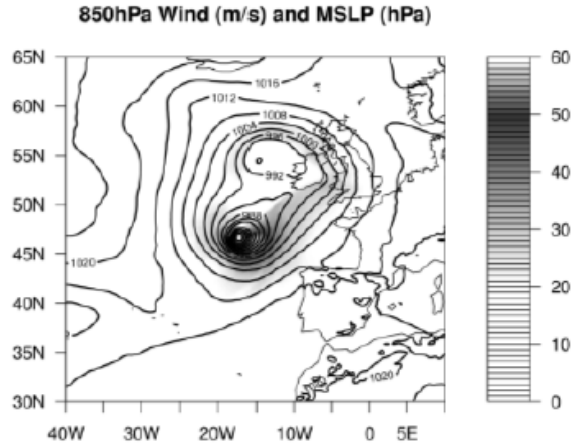
Increase is largest for autumn.

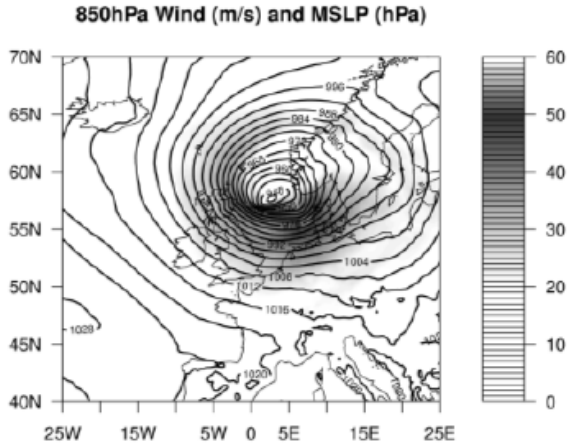
Risk for trees, agriculture

A similar storm as Ophelia following a similar path is present in the 2090 data set

EC-Earth simulation

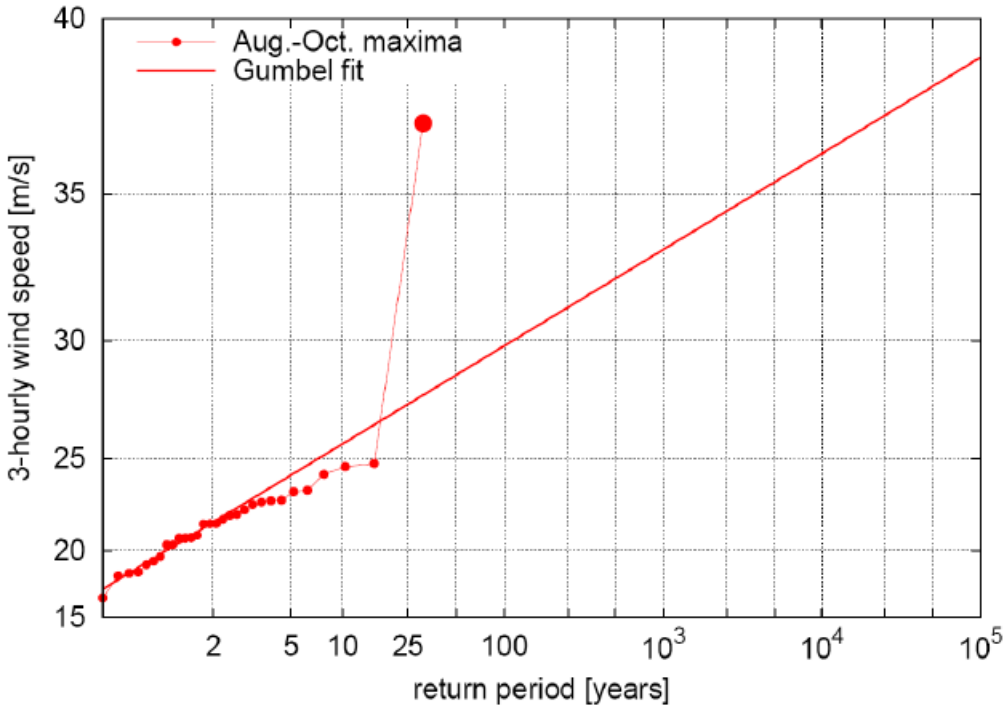






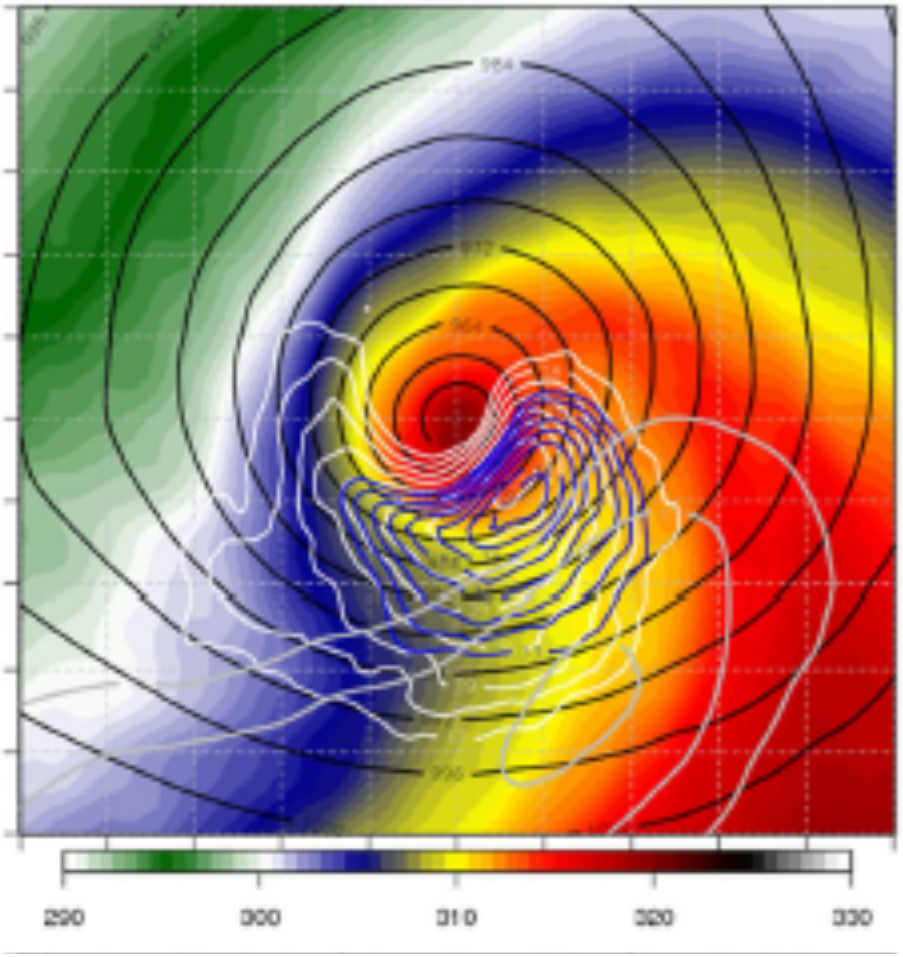
When entering Europe it underwent extra-tropical transistion similar as Ophelia

This storm produced extreme winds over the North Sea



Structure of severe post-tropical cyclones entering Europe

Warm-seclusion structure



shading: equivalent potential temperture

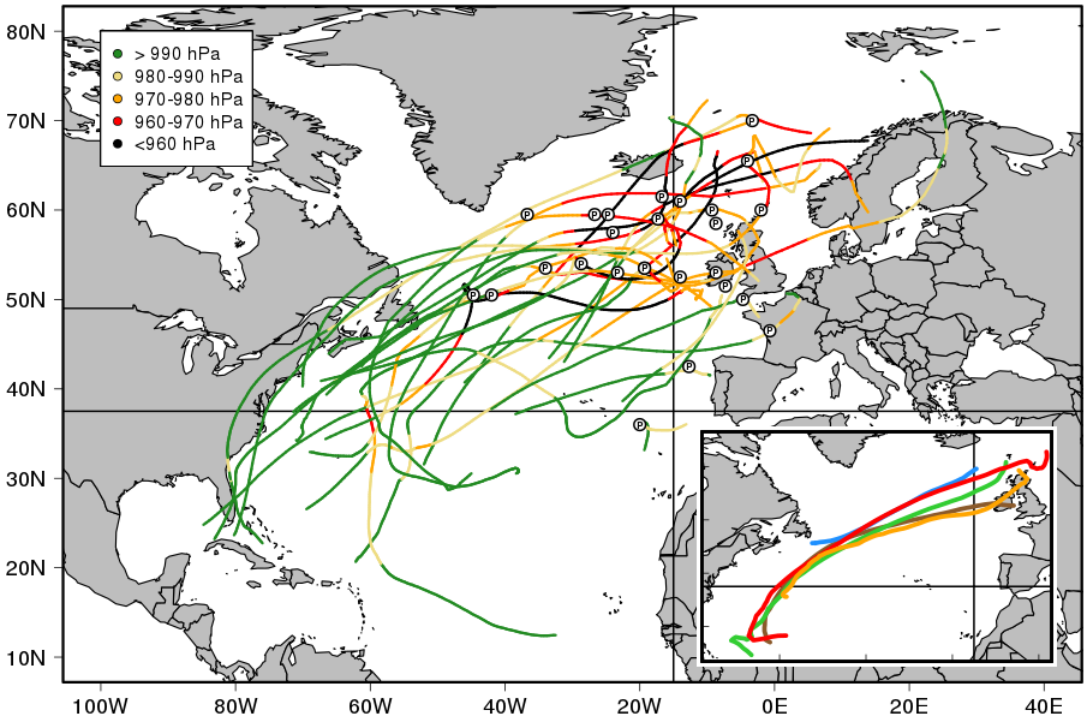
Thick black isolines: MSLP

Thin solid lines: windspeed

Baatsen et al. 2015

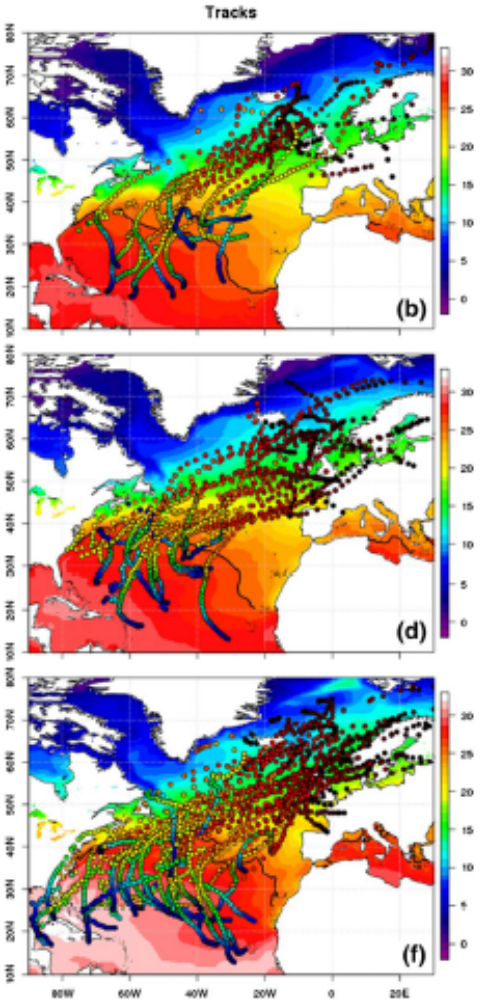
Analysis of MERRA reanalysis (1979-2016) confirms warm seclusion structure

Dekker et al., Clim. Dyn., 2018



Ophelia was also a warm seclusion storm

Increase in storms reaching Europe is already visible in 2035



present

2035

2090

Is Ophelia first sign of future changes ?

Much more analyses is needed for robustness.

PRIMAVERA and HighResMIP simulations

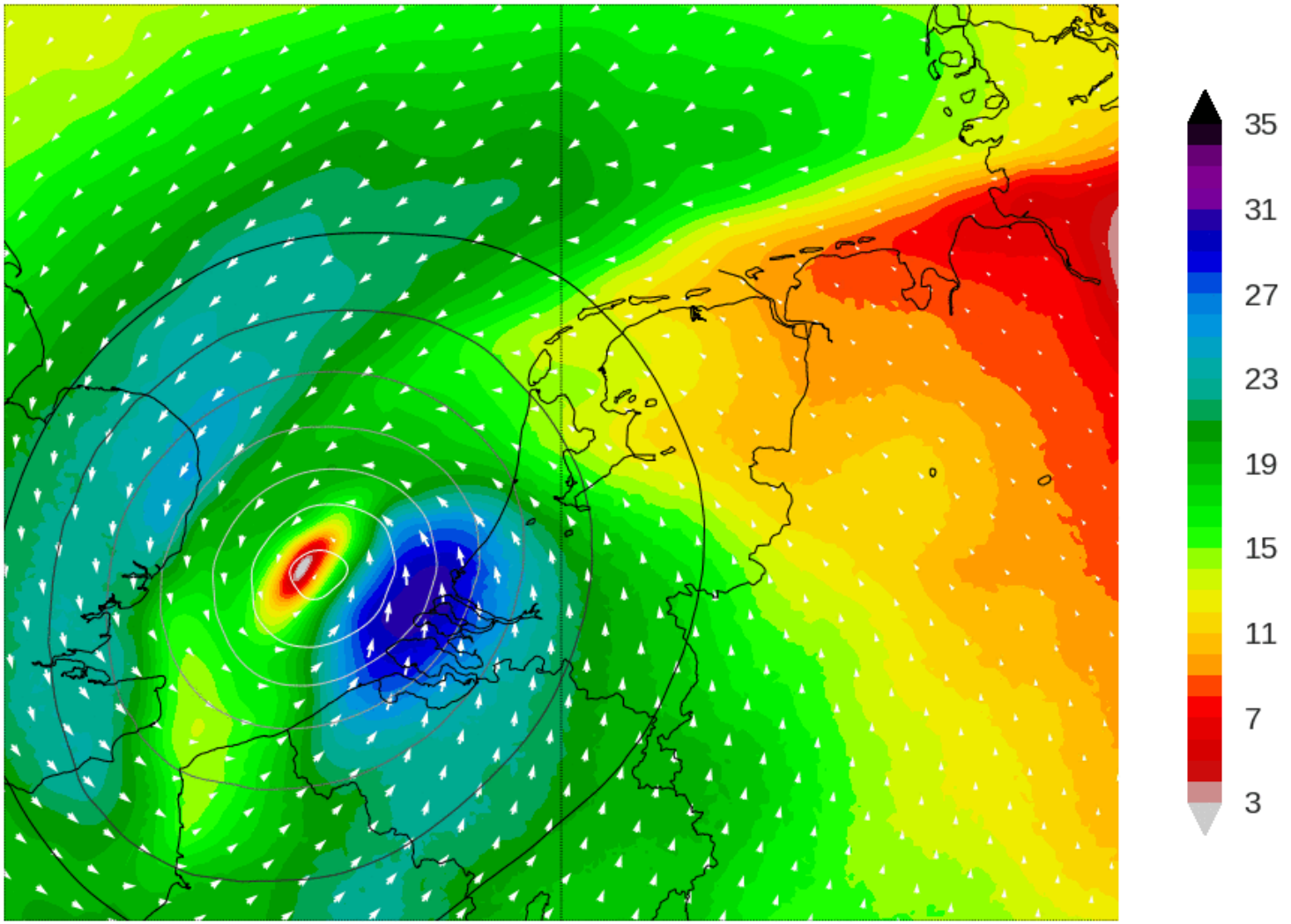
What would be the consequences for the Netherlands if Ophelia had taken a more easterly track?

Specific question from the government
Risk of storm surges

Experiment: redirecting Ophelia using regional climate model (RACMO)

De Vries et al. In prep.

Wind speed (t=20171016-00)
HCLIM38h1_OPH_an2017101600_expb



PÖYRY

University of Reading

PRIMAVERA

PRIMAVERA USE CASE:
USE OF HIGH-RESOLUTION GCM SIMULATIONS FOR HYDROLOGICAL AND HYDROPOWER IMPACT RESEARCH IN THE UPPER DANUBE BASIN

Philipp Stanzel, Paula Gonzalez, Harald Kling, David Brayshaw

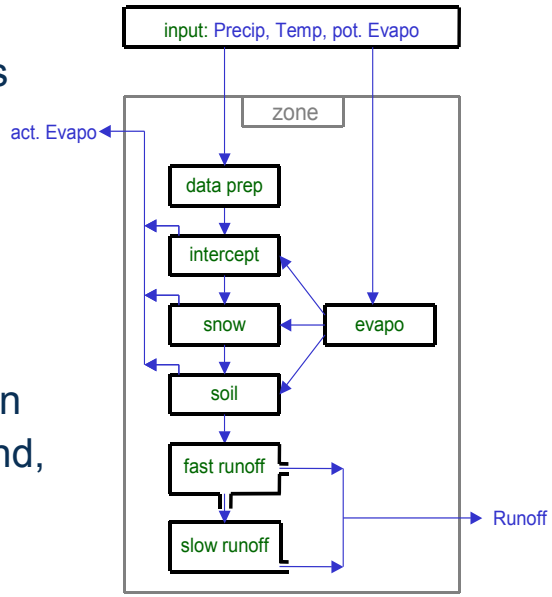
EGU PRIMAVERA splinter session, April 2018

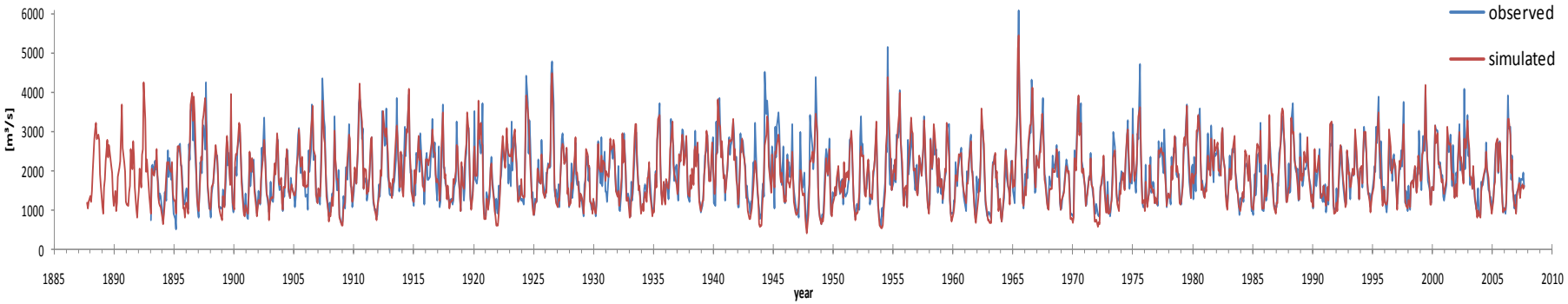
CLIMATE CHANGE IMPACT RESEARCH FOR THE UPPER DANUBE

- Danube River in Germany and Austria:
  - important waterway
  - ecologically vital flood plains
  - hydropower generation at the main river and many tributaries
- Basin upstream of Vienna: 100,000km²
- Alpine foothills and lowland Danube catchment, Alpine Inn catchment

CLIMATE CHANGE IMPACT RESEARCH FOR THE UPPER DANUBE

- Monthly conceptual water balance model
- 61 model zones based on elevation bands and subbasin boundaries
- Input data: precipitation, air temperature, ETP
- Historic simulation for an exceptionally long period from 1800
- Climate change impact scenarios for the 21st century simulated by using bias corrected climate model data as input
- Previous applications: ENSEMBLES and CORDEX data (for German Federal Institute of Hydrology BfG, Austrian Climate and Energy Fund, Austrian Ministry of Transport)





Runoff simulation 1887 to 2007. Simulated and observed monthly runoff of the Danube at Vienna.

HIGH RESOLUTION GCM DATA FROM PRIMAVERA

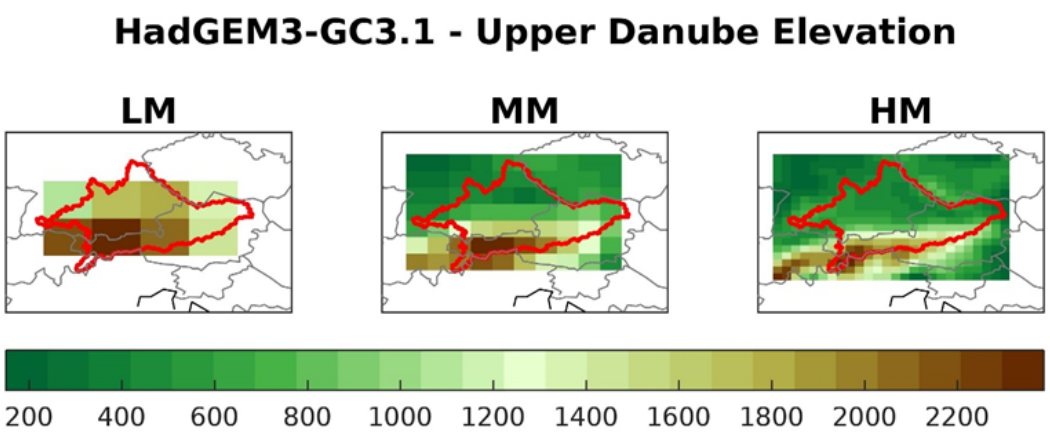
In the framework of the PRIMAVERA project, GCM simulations with high horizontal resolutions are generated by seven climate modelling consortia. The simulations are conducted following the CMIP6 HighResMIP protocol (Haarsma et al. 2016). The experiments are divided into 3 tiers consisting of atmosphere-only and coupled runs and spanning the period 1950-2050, with the possibility of extending to 2100.

In the presented initial assessment, six different realizations of HadGEM3-GC3.1, the GCM developed by the MetOffice/Hadley Centre, University of Reading and the NERC are used, for both forced and coupled versions of the GCM, at three horizontal resolutions: 100 km, 50 km and 25 km.

ADDITIONAL PRIMAVERA SIMULATIONS

Institution	MOHC, UREAD, NERC	EC-Earth: KNMI, BSC, SMHI, CNR	CERFACS	MPI-M	AWI	CMCC	ECMWF
Model name	HadGEM3 GC3.1	EC-Earth3	CNRM-CM6	MPIESM-1-2	AWI-CM 1.0	CMCC-CM2	ECMWF-IFS
Model components	UM, NEMO, CICE	IFS, NEMO, LIM	ARPEGE, NEMO, GELATO	ECHAM, MPIOM	ECHAM, FESOM	CAM, NEMO, CICE	IFS, NEMO, LIM
Atmos nominal resolution	100, 50, 25	100, 50	250, 50	100, 50	250, 100	100, 25	50, 25

Acronym	Forcings (e.g. GHG, ocean conditions)	Horizontal resolution
MOHC_LL_coupled	Historic 1950-2014 forcings / coupled to ocean model	100 km
MOHC_LM_forced	Historic 1950-2014 forcings / observed sea surface temp.	100 km
MOHC_MM_coupled	Historic 1950-2014 forcings / coupled to ocean model	50 km
MOHC_MM_forced	Historic 1950-2014 forcings / observed sea surface temp.	50 km
MOHC_HM_coupled	Historic 1950-2014 forcings / coupled to ocean model	25 km
MOHC_HM_forced	Historic 1950-2014 forcings / observed sea surface temp.	25 km

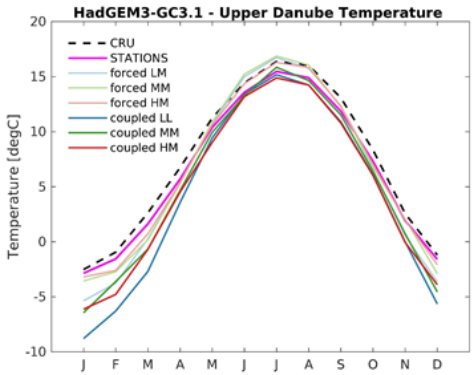


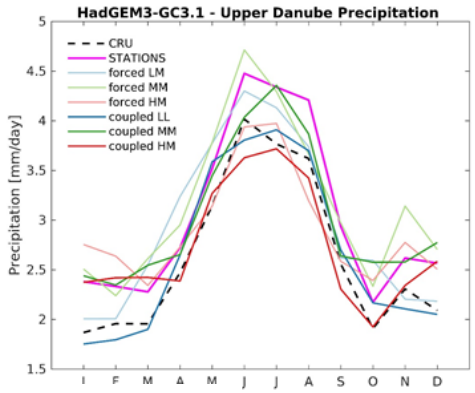
HISTORICAL GCM SIMULATIONS AT THE BASIN SCALE

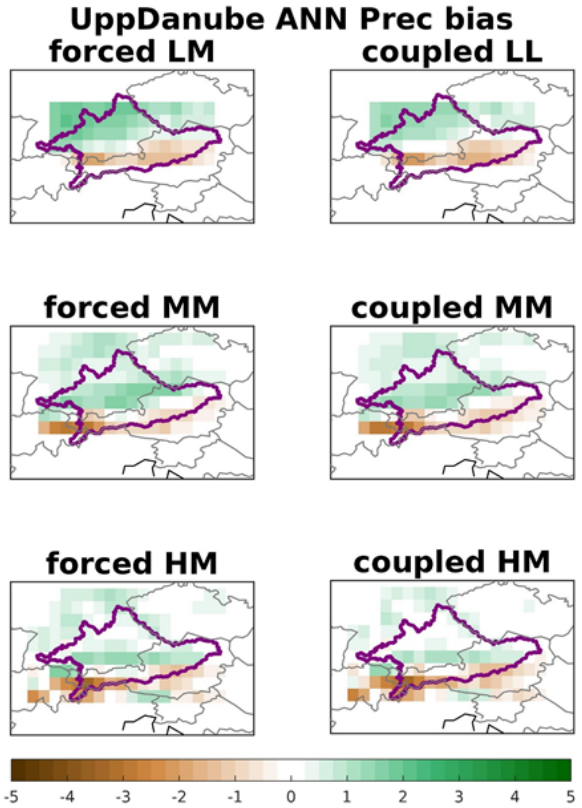
Over the entire Upper Danube basin, historical means of precipitation and temperature for the period 1961-1990 were compared against the observational CRU TS3.25 data set, at its 0.25° resolution, and with station-based basin averages.

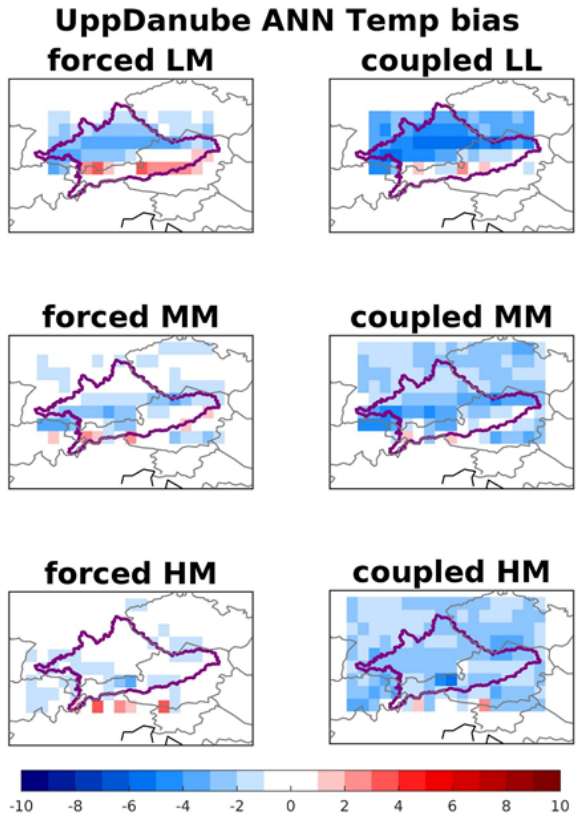
Seasonality of temperature and precipitation is captured very well for the basin average, but a significant cold bias is observed especially in the coupled model runs. The bias is larger compared with CRU than with the station average.

The spatial results reveal a dry bias over the Alps and a wet bias over the lowlands, though the latter one reduces significantly with increased resolution. For temperature, cold biases dominate the region, with warm biases over small parts in the highest alpine areas. Small areas with significant cold bias in the central southern part of the basin were shown to lead to large errors after downscaling to the scale of the hydrological model.









PÖYRY

HISTORICAL GCM SIMULATIONS AT THE SCALE OF HYDROLOGICAL MODEL ZONES

PRECIPITATION

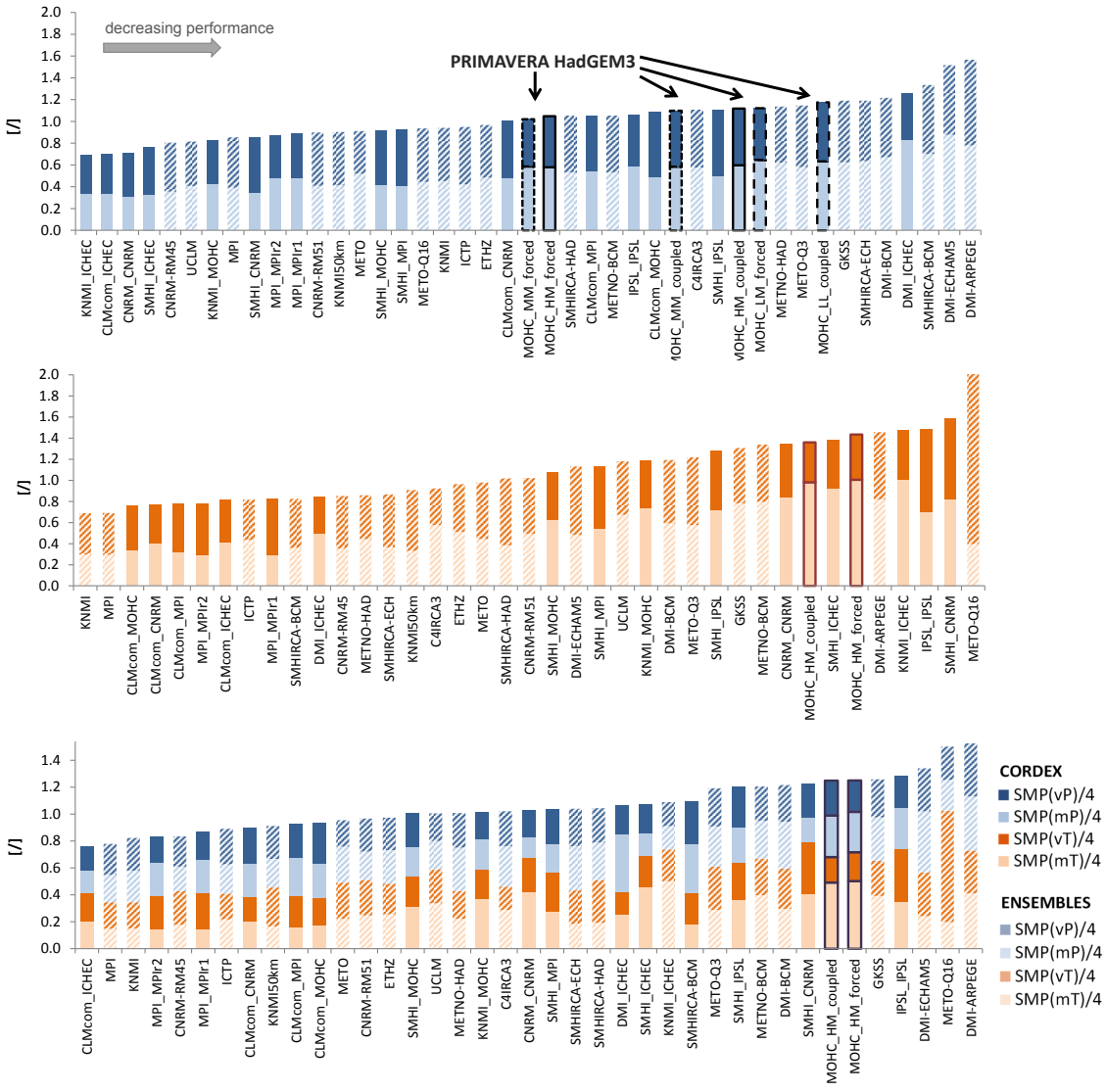
- PRIMAVERA HadGEM3 realizations with higher resolution generally perform better than with lower resolution
- Compared with ENSEMBLES and CORDEX RCMs, their skill is in the range of or slightly lower than the median RCM

TEMPERATURE

- Downscaling based on a local elevation gradient was not possible with coarse resolution PRIMAVERA GCMs
- Temperature bias of the HM HadGEM3 realizations are higher than in most RCMs
- Low model performance can be traced back to specific GCM cold bias errors in low-lying areas of the Austrian Alps

OVERALL PERFORMANCE

- Overall skill in representing historic climate is lower in high resolution HadGEM3 realizations than in most RCMs , mainly due to temperature bias



CONCLUSIONS AND OUTLOOK

FIRST CONCLUSIONS

- Coarser PRIMAVERA GCM resolutions are not suitable for specific methods of temperature downscaling
- Higher resolution GCMs show lower bias in temperature and precipitation over the Upper Danube basin than lower resolution realizations
- Precipitation bias in high resolution HadGEM GCMs is in the median range of RCM bias
- Temperature bias in high resolution HadGEM GCMs is higher than in most RCMs, due to strong cold bias in specific model regions.

NEXT STEPS

- Include more high resolution PRIMAVERA GCMs to investigate model representation of historic climate (ECMWF and CMCC models are being considered for reaching a 25km resolution)
- Generate scenarios of hydrological change in the 21st century based on GCM scenario runs
- Comparison of PRIMAVERA GCM impact scenarios with previous RCM impact scenarios
- Assessment of implications for future hydropower production along the Danube

DISCUSSION GROUPS

You can select between the four discussion topics:

Use of PRIMAVERA results

Pros & cons of HR

Engagement approaches and how to improve them

Relevant climate impacts

FEEDBACK FROM THE DISCUSSION GROUPS

EGU SURVEY ON EXPERIENCE WITH THE HORIZON 2020 PROGRAMME

www.egu.eu/H2020survey/